



Efforts to Characterize Ground Water Quality in Indiana through the Statewide Ground Water Monitoring Network

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Funding

- Statewide Ground Water Monitoring Network (GWMN) made possible in part by the Clean Water Act Section 106 funding
- Sampling of ground waters across the state seeks to determine the following:
 - How ground water may affect the quality of surface waters
 - The recharge/discharge relationships of ground water including surface water/ground water interaction
 - How source water and drinking water supplies can best be protected by utilizing data derived from a comprehensive approach to assessment and monitoring



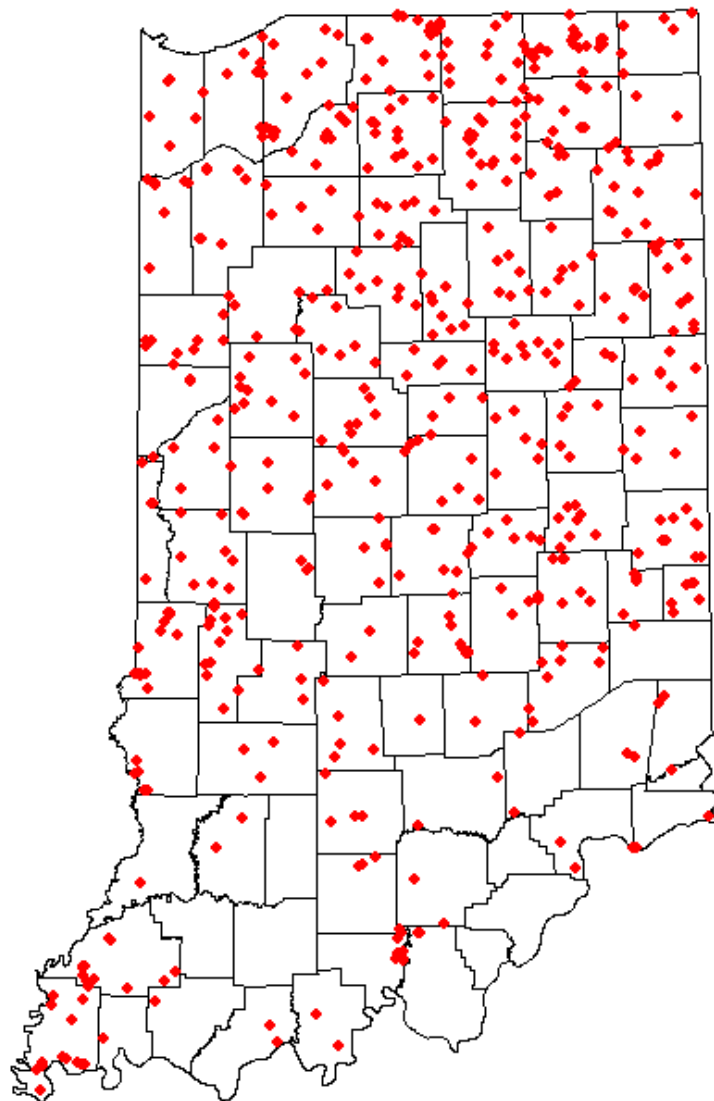
Goals of the GWMN

- Determine ambient quality of ground water of the state by sampling private residential wells and public water supply wells across Indiana
- Characterize the ground water quality in hydrogeologic settings so that predictions about the ground water resources can be made
- Provide the public with access to the data
 - Participants
 - Interested groups



GWMN Site Locations

- **607 sites sampled since 2008**
 - 359 private well sites (residential)
 - 248 public well sites (non-community, such as churches, schools, businesses)
- **Site selection during initial rounds**
 - Previous sampling networks
 - Ground water availability/population
 - Corresponding well log required





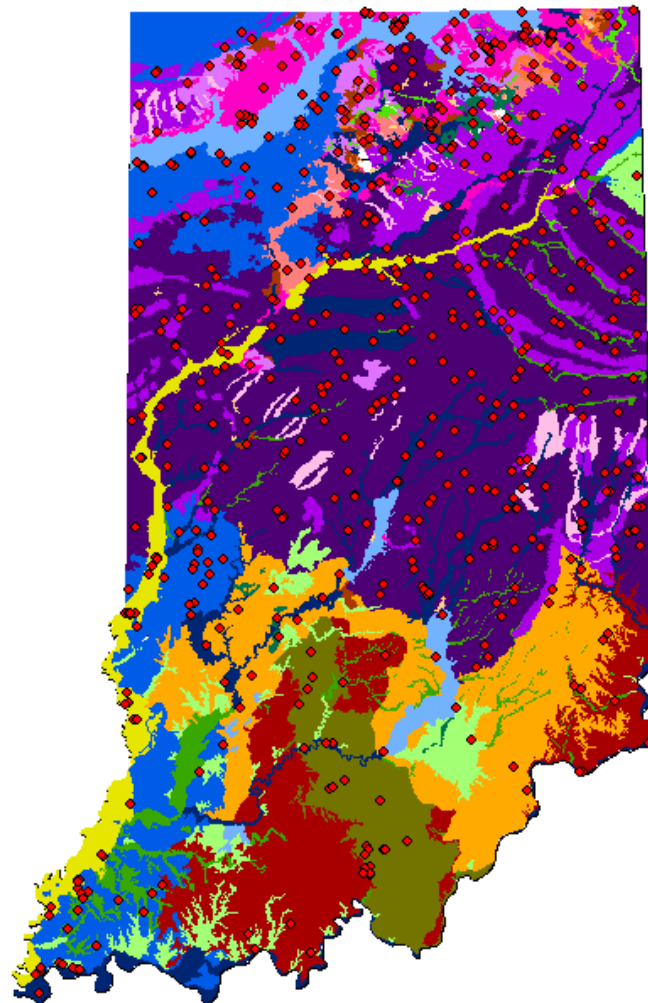
GWMN and Hydrogeologic Settings

- **Hydrogeologic Settings**

- Indiana Geological Survey classification scheme providing settings to help interpret the occurrence, movement and sensitivity to contamination of ground water (Fleming et al., 1995)
- Over 240 settings, narrowed down into 20 “general” settings, such as Till Plain, Alluvial Valley, etc.

- **Aquifer Sensitivity**

- High: 289 sites
- Moderate: 104 sites
- Low: 176 sites
- Variable: 38 sites



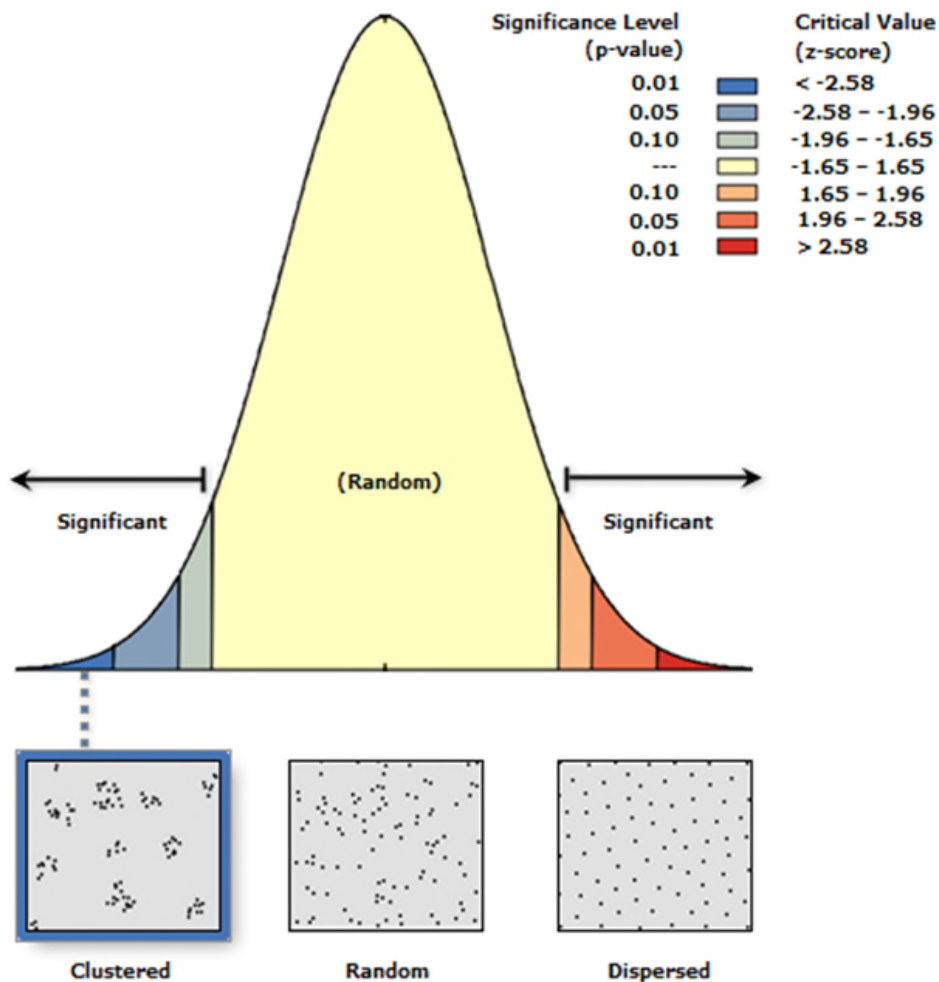


GWMN, Phase 1

- Consisted of five rounds of sampling between 2008 and 2012
- Limited trend sampling
- Spatial distribution of sampling locations was not random
 - Clustering of sample sites
 - Some aquifer types/settings over/underrepresented



Spatial Statistics of the GWMN



**Average nearest neighbor
summary results**

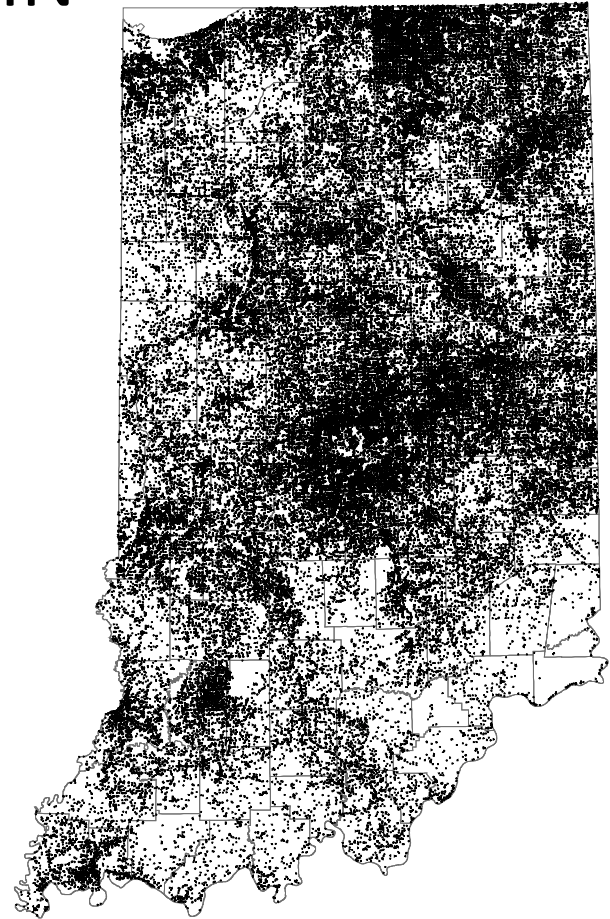
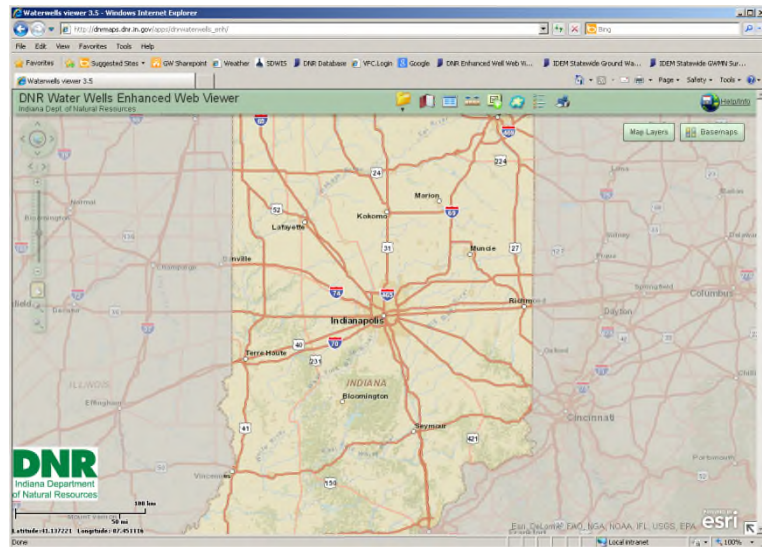
**Nearest Neighbor Ratio:
0.596307**

**z-score: -6.368484
p-value: 0.000000**



2013 Revised Design of the GWMN

- Sample population consists of all 146,507 drinking water wells in the Department of Natural Resources database that have a located well log





Revised Design of the GWMN

- Used a simplified version of the Yamane (1967) formula to calculate the number of samples needed to represent the sample population

$$n = \frac{N}{(1 + N(e)^2)}$$

Where: n = sample size
N = total population
e = level of precision (95%)

- From this, the statewide drinking water well population can be represented by 398 samples
- The samples will be proportionally distributed through the 20 lumped hydrogeologic settings through stratified sampling

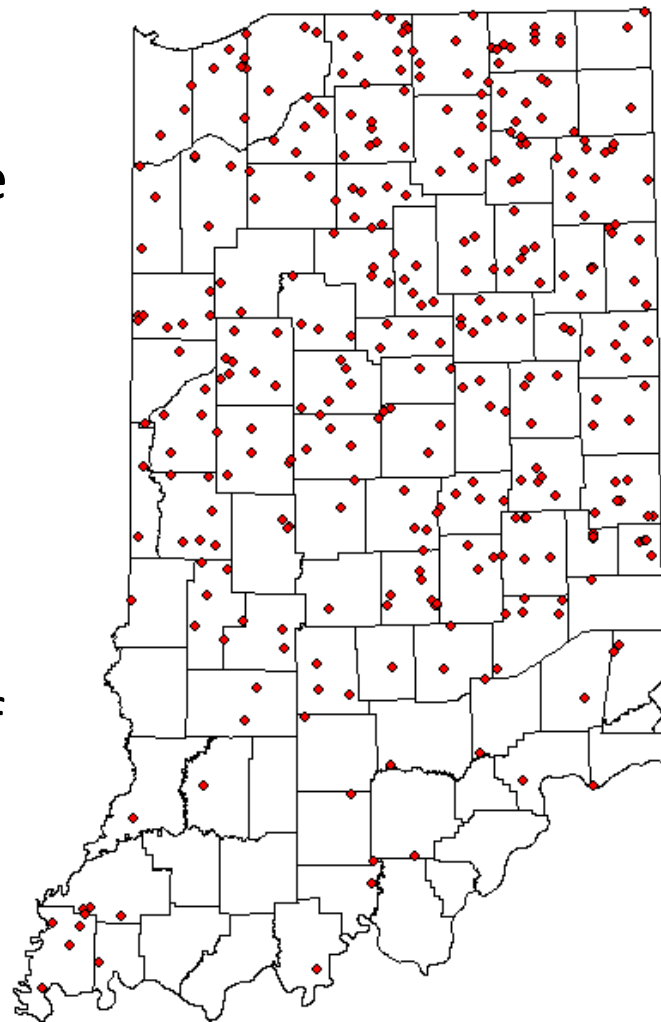


Geologic Setting	Located DNR Wells	% Located Per Setting	Weighted Sample Size
Ablation Sequence	1,604	1.09%	4.37
Alluvial Valley	1,894	1.29%	5.16
Dissected Bedrock	1,945	1.33%	5.30
Dissected Bedrock Thin Till	6,397	4.37%	17.42
Fan Head Complex	1,859	1.27%	5.06
Ice Contact Deposits	386	0.26%	1.05
Karst Plain and Escarpment	3,500	2.39%	9.53
Lake Deposits	2,093	1.43%	5.70
Meltwater Channel	380	0.26%	1.03
Outwash Complex	1,959	1.34%	5.33
Outwash Plain	8,298	5.66%	22.59
Sand Plains and Loess Sands	11,732	8.01%	31.94
Sluiceway or Discrete Channel	12,723	8.68%	34.64
Till Capped Fan	3,271	2.23%	8.91
Till Cored Moraine	16,168	11.04%	44.02
Till Plain	56,234	38.38%	153.11
Trough System	1,549	1.06%	4.22
Tunnel Valley	3,682	2.51%	10.03
Unconfined Outwash Fan	6,410	4.38%	17.45
Wabash River Valley	4,330	2.96%	11.79



2013 GWMN Network Design

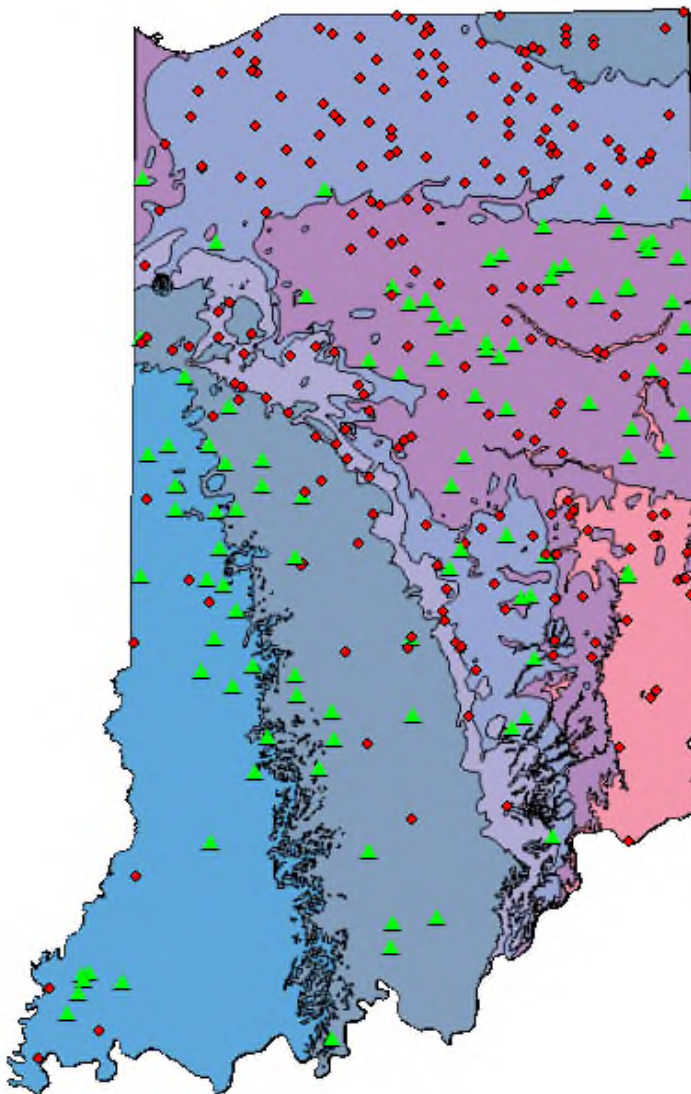
- 198 sites that were previously sampled as part of the GWMN were retained
 - Randomly selected by lumped and individual hydrogeologic setting
- 132 additional sampling sites were identified and brought into the network
- 330 sites sampled in 2013 as part of Round 6





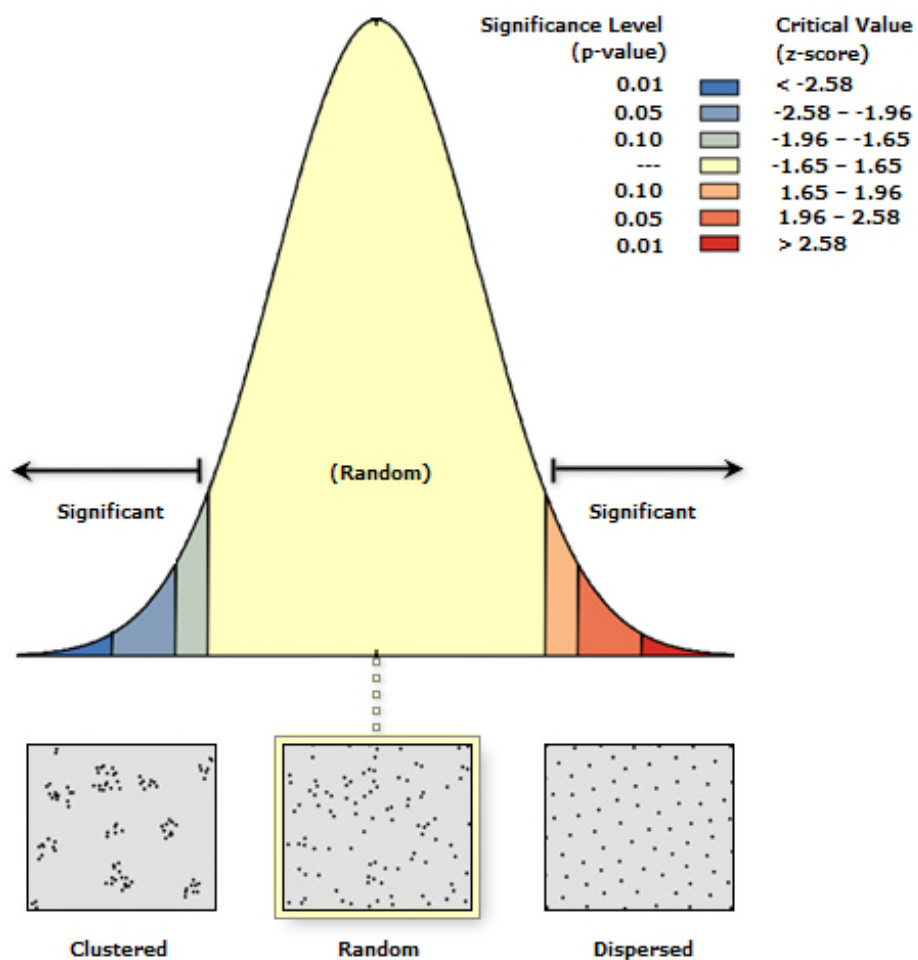
Bedrock Aquifer Sampling

- # Sampled, Bedrock
- Sampled, Unconsolidated





2013 Spatial Statistics of GWMN



Nearest Neighbor Ratio: 0.975788

z-score: -0.845248

p-value: 0.397972

Given the z-score of -0.99, the pattern does not appear to be significantly different from random.



Sampling the Sites: Field Parameters

- Purge well for ~ 15 minutes
- Field Parameters
 - Temperature, Specific Conductivity, Dissolved Oxygen, pH, Oxidation Reduction Potential





Sampling the Sites: Analytical Parameters

- Analytical Parameters
 - Unfiltered: Volatile Organic Compounds, Synthetic Organic Compounds, Pesticides, Unregulated Pesticide Degradates
 - Filtered: Metals, Inorganic Ions, Alkalinity, Nitrate-Nitrite





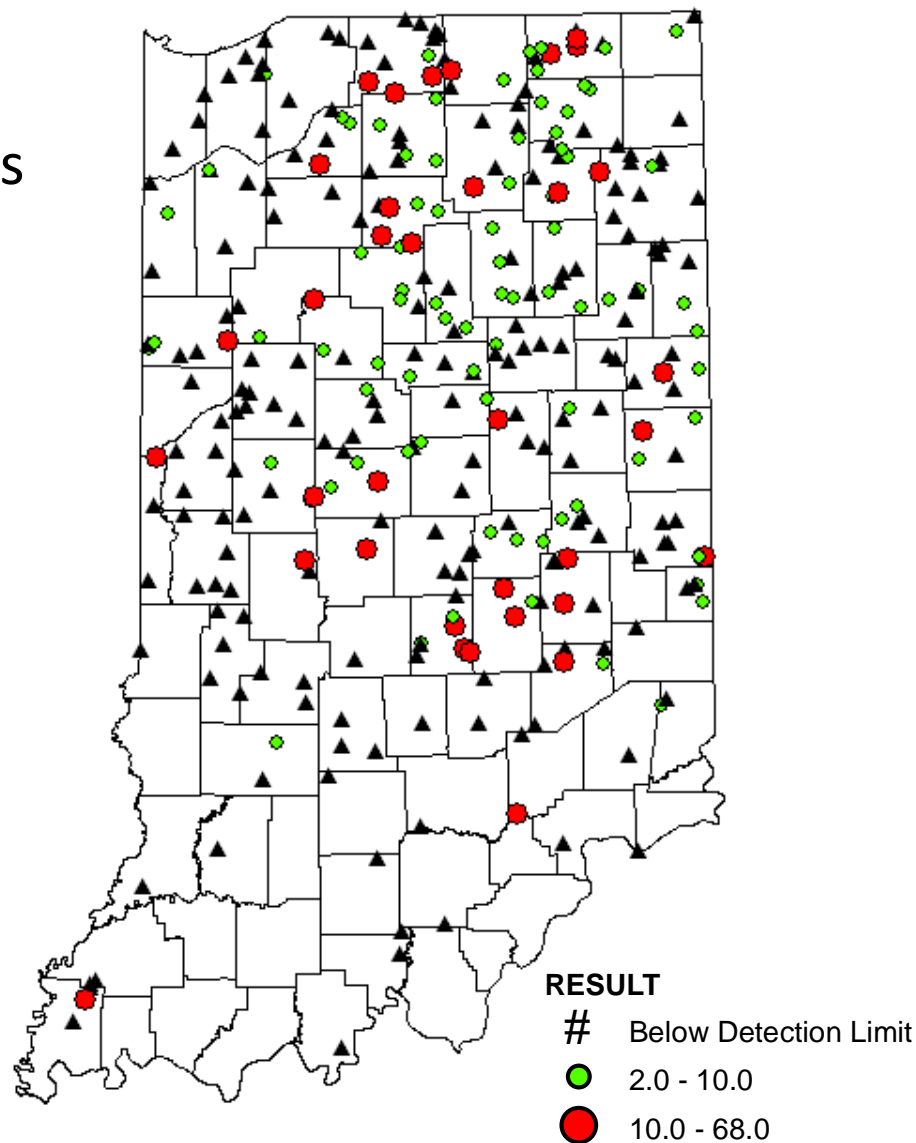
2013 Results

- Number of samples collected: 330
- Still have 68 samples to collect to complete the 1st round of statistically based sampling
- Most samples did not have notable contamination



2013 Arsenic Results

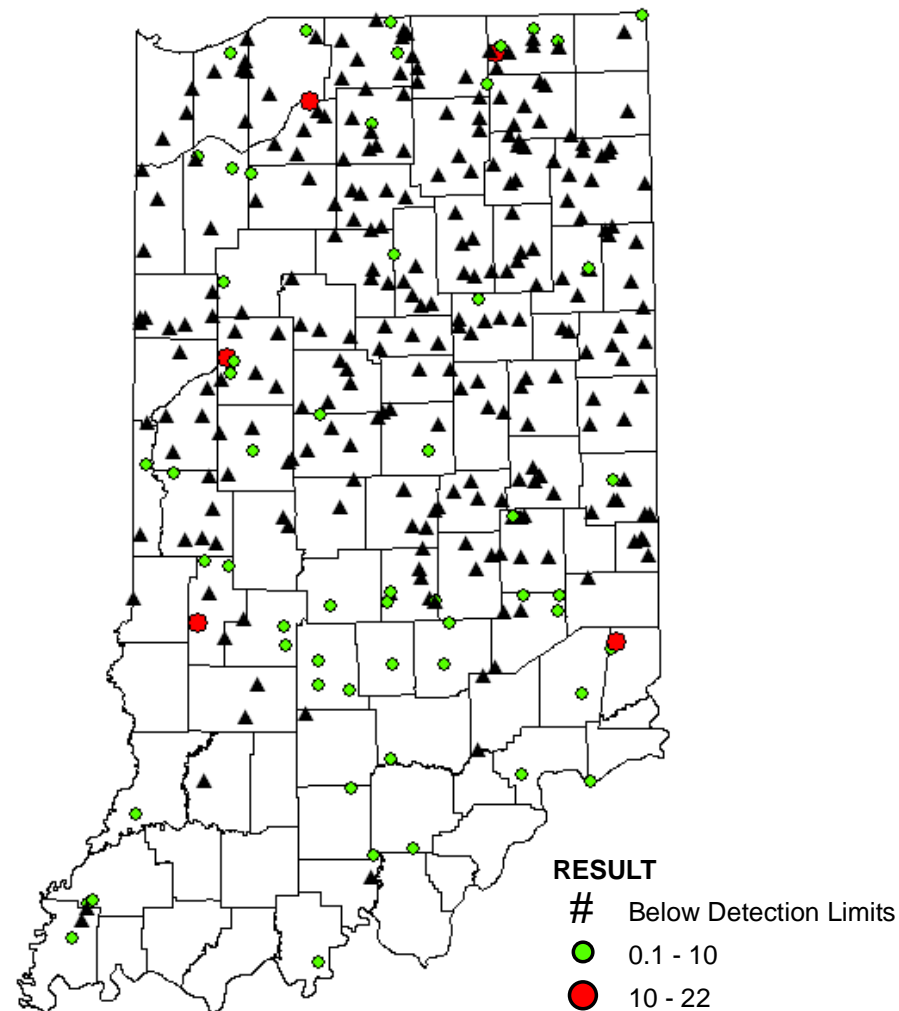
- Arsenic detected in 120 samples (36%)
 - **30% of detections** in high sensitivity aquifers
 - 44% in low sensitivity aquifers
- Exceeds the U.S Environmental Protection Agency (U.S. EPA) Maximum Contaminant Level (MCL) of 10 ppb in 36 samples (11%)





2013 Nitrogen, Nitrate-Nitrite Results

- Nitrogen, Nitrate-Nitrite detected in 35% of samples
 - 49% of detections in high sensitivity aquifers
 - 30% of detection in low sensitivity aquifers
- Exceeds the U.S. EPA MCL of 10 mg/l in 5 samples (1.5%)





2014 GWMN Activities

- Collect the remaining samples needed to complete Round 6
- Bring new sites into the network to complete an additional round of statistically based sampling
 - Sign-ups a challenge
 - GWMN website



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